The Report Committee for Tricia Marie Jarrott
Certifies that this is the approved version of the following report:

Effective Professional Development Practices to Elicit Changes in Teaching Evolution

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor: ______________________________
Edward Theriot

____
Mary Walker

Effective Professional Development Practices to Elicit Changes in Teaching Evolution

by

Tricia Marie Jarrott, B.S.

Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Masters of Arts

The University of Texas at Austin

August 2011

Dedication

This report is dedicated to my family, who have given me the support, patience and encouragement I needed to fulfill this degree. I appreciate everything that all of you have done for me.

With much love for all of you,
Trish

Acknowledgements

I offer my deepest gratitude to everyone at the Texas Natural Science Center at the Texas Memorial Museum. I specifically am indebted to Dr. Ed Theriot for allowing me to work in the museum and with his wonderful staff; to Christina Cid for her constant support and encouragement; and to Dr. Pamela Owen and Laura Naski for the opportunity to learn about paleontology and biological evolution from two of the best teachers I've ever worked with. All of you inspire me, thank you for all of the opportunities.

Abstract

Effective Professional Development Practices to Elicit Changes in Teaching Evolution

Tricia Marie Jarrott, M.A.

The University of Texas at Austin, 2011

Supervisor: Edward Theriot

With numerous opportunities for professional development, teachers are inundated with a variety of workshop styles to choose from. In the development of the Life Through Time workshop, we have made every attempt to consider recent research that outlines the most effective methodologies in professional development implementation including consideration of existing conceptions, teacher motivation, and highly reflective engagement. The intention of this long-term professional development is to motivate teachers to implement changes in the delivery of content related to evolution in the science classroom. After reviewing the strategies implemented in this professional development opportunity, practices that were used can be extended to future teacher training programs.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction: *Background Information 1.1*

Teachers are subjected to a variety of professional development formats throughout their careers. The goal for all professional development is to provide new knowledge and skills that elicit a change in the teachers' classrooms. Examples of these changes include changes in curriculum content, changes in classroom management styles, changes in pedagogy, changes in scope and sequence, change in motivation to teach specific content, change in resources used to teach concepts, implementing more field work or field investigations, or a combination of these changes. From these workshop experiences, they are expected to extract the appropriate skills, strategies, or content that is to be taken back to their respective classrooms and implement them to improve instruction. This places an immense responsibility on teachers to gain as much content/skill/strategy/knowledge as possible, and then convert the newly acquired learning into curriculum content or pedagogical practices that result in academic gains for their students. Most of these professional development opportunities encourage teachers to facilitate the students' learning, rather than offering direct instruction. Teachers are rarely asked to participate in professional development in the same ways that have been shown effective with students (Lieberman, 1995). Additionally, when the challenge of dealing with what is perceived as controversial curriculum (such as the topic of evolution) is added to the mix of professional development, teachers are in need of tailored professional development that will help them implement new curriculum.

Workshop Objectives 1.2

The research presented in this report is based on extensive work with the Texas Natural Science Center (TNSC) and their presentation of their Life Through Time (LTT) workshop for teachers. The goal was to provide effective long-term professional development for 20 teachers that focused on the teaching of evolution concepts. After much reading and review of several professional development models and best practices at eliciting change, a series of workshops was developed and implemented that included increasing content knowledge, best practices in teaching evolution, curriculum to take back to the classroom, an arena for reflection and discussion of implementation, and a partnership with university research scientists and the museum that allows teachers to have access to materials and equipment to use in their classrooms. The focus of this research is on evolution because it is often viewed as a controversial and therefore a challenging topic to teach. Since evolution is not a new objective in science education, it would be prudent to consider how professional development addresses the strategies or implementation of evolution instruction. Professional development strategies, similar to those used in the LTT training, should be transferable to other challenging instructional topics. The research question to be answered in this report is what is the effect of a reform-based professional development series on how teachers approach teaching evolution?

Scope of the Workshop 1.3

To begin the professional development series, 20 teachers were selected from a large application pool. Criteria used to select the teachers was determined by the LTT team, and was laid out in the grant expectations for the Institute of Museum and Library Services (IMLS), Museums for America grant. Basic requirements included teaching 4^{th}-8^{th} grade as the workshop curriculum was aligned with the 4^{th}-8^{th} grade Texas Essential Knowledge and Skills (TEKS), with an emphasis on those who teach a majority of students who are underrepresented in the sciences including Hispanics, African-Americans and females.

Upon selection for the group, teachers agreed to attend a 9 day, integrated life and earth science teacher training series where they would work collaboratively with University of Texas scientists and science educators to explore change over time. Participants also agreed to train other colleagues and to implement life through time curriculum in their classrooms. A Blackboard website was utilized to allow teachers to reflect on their learning, pose questions to one another or collaborating research scientists, and describe challenges or misconceptions they face in implementing life through time curriculum. Additionally, teachers complete pre- and post tests to determine changes in content knowledge, logs that document integration of project curriculum into their teaching, program evaluations, and logs documenting training of other educators.

Participating teachers attended two days of workshop training in the Spring of 2011, an additional five days of training in the Summer of 2011, and are scheduled to attend a final two days of training in the Fall of 2011. The focus of each of these days has been different, but includes the following life through time topics: introduction to geology; geological time; fossils and fossilization; paleontology; biodiversity; organisms and their environment; environmental change, evolution and extinction; plate tectonics; and the Tree of Life.

Sessions were planned and conducted collaboratively with the museum's director of education, a lead teacher, university research scientists, and museum staff based on state and national science education standards, science educators' recommendations, and literature review of challenges teachers face in teaching evolution. Participating teachers received a stipend for their participation, curriculum guides and classroom activities presented in the workshop, field trips to multiple research facilities and collections sites, and continuing professional education credits for their time. Anticipated benefits at the conclusion of the workshop series include: increased content knowledge of life through time and the ability to teach associated concepts; materials and experiences that can be integrated into teaching; access to Texas Natural Science Center (TNSC) resources, including science staff, loaner kits, exhibits, and field activities; opportunity to collaborate with cohort colleagues, TNSC scientists and science educators to share lesson ideas, reflect on learning and ask questions; and the ability to become a teacher leader by using the knowledge, skills and resources gained during training sessions to train others.

Organization of Report 1.4

The remainder of this report is broken into chapters that reflect the additional research conducted to complete this report. Chapter 2 includes a literature review related to traditional professional development models and suggestions for reform, as well as challenges teachers face in teaching evolution and evolution concepts. The qualitative method used to collect data from teachers, as well as conclusions of the workshop study and recommendations for further studies is discussed in Chapter 3. In Chapter 4, applications to practice are discussed.

Chapter 2: Literature Review: *Stress in the Classroom 2.1*

Teaching is a stressful job, whether it is internal stress stemming from a teacher's lack of confidence, lack of resources, or external stress provided by parents, administrators, and/or the community that can arise when topics perceived as controversial are to be taught in the classroom. In 1997, a report from the United States Department of Education detailed that 34% of teachers would not choose the same profession given the opportunity to start all over again. In addition to their dissatisfaction with pay, teachers reported that they felt stress from not having support, time or the knowledge to appropriately handle stress. Professional development is an excellent means to transfer skills to teachers in order to minimize some of these stresses (Griffith & Brem, 2004). Effective professional development should strive to identify the root of teacher stress and remedy the problem by addressing those needs directly. By having a better understanding of what may cause anxiety in teachers when it comes to particular content, we can better prepare them for effective classroom instruction. In fact, "Understanding what teachers need to be more comfortable and confident in their profession is crucial to the future of effective teachers and scientific literacy in public schools" (Griffith & Brem, 2004). When teachers are confident in the content they teach, they are more effective teachers and they have the ability to increase scientific literacy in their classrooms (Griffith & Brem, 2004).

Evolution is an example of a controversial topic in the science classroom, and teachers employ several strategies to teach the subject. Some teachers feel significant pressure to juggle the demands of teaching evolution as their profession prescribes, which may conflict with their own personal beliefs, and the concerns of the communities they service. While much attention has been paid to teachers internal and external conflict over teaching evolution, very little is known about what teachers' perceptions, reactions, and coping strategies are (Griffith & Brem, 2004).

When teachers experience stress, they develop coping strategies. However, effective coping strategies involve "extensive reflection, work, and guidance." Without the opportunity to reflect, coping strategies will still be formed, but the teacher may continue to experience the discomfort of stress because the coping strategies they are employing are not effective or give rise to new problems (Griffith & Brem, 2004). When dealing with evolution specifically, teachers need to confront the conflict that they experience head on in order to develop effective coping strategies. Giving them the opportunity to do so, in a supportive professional development setting, can pave the way for increased teacher satisfaction and an alleviation of stress (Griffith & Brem, 2004; Lieberman 1995).

Not all science teachers experience high levels of stress when confronted with teaching evolution in the classroom. According to qualitative data presented by Griffith and Brem in their research on *Teaching Evolutionary Biology: Pressures, Stress, and Coping*, teachers that were found to have a passion for science and believe that evolution is an integral part of science education experience very little stress. These teachers do not believe that teaching evolution will have any negative impacts on their students. Perhaps most importantly, "Their strong sense of what is and is not appropriate in the classroom reduces the opportunity for situational stressors to surface" (2004). The goal of the LTT workshop series is to provide teachers the opportunity to identify their level of stress and to provide a supportive environment for them to develop appropriate coping skills through a better understanding of what the nature of science is, appropriate strategies in teaching evolution, and copious opportunities for reflection to create new understandings and knowledge.

Evolution Teaching Strategies 2.2

When considering strategies for teaching evolution, it is important to pattern professional development instruction after what teachers are used to doing in their own classrooms with their own students. For this research, teachers in 4^{th}-8^{th} grades are the focus because these grades lay the groundwork for concepts in evolution that are to be delved into further in high school. This groundwork could be in the form of the nature of science, the ideas of change over time in relation to Earth's history, or geologic time. Therefore, the concepts and practices conducted in LTT training were most closely related to these same topics. The goal of this professional development was to give participants the opportunity to have a trial run at new content that could be implemented in their own classroom. In *Practices that Support Teacher Development: Transforming Conceptions of Professional Learning*, Lieberman states "what everyone appears to want for students- a wide array of learning opportunities that engage them in experiencing, creating, and solving real problems, using their own experiences, and working with others- for some reason is denied to teachers" (1995). We purposefully decided to make sure the same learning opportunities that are encouraged when working with students, were taken into consideration when planning the workshop series for teachers.

One of the strategies that must be addressed at the forefront is establishing a science based vocabulary. Asserting what science is, as well as what it is not, may help to remedy many of the challenges teachers face with evolution instruction. “Understanding how professional associations use the terms ‘truth,’ ‘belief,’ ‘theory,’ etc. can make an important contribution to the clarity of a teacher’s communication” (Scharmann, 2005). An example of this was the clarification made in the first day of the workshop in distinguishing the difference between a scientific theory and the common use of the word, theory. Keeley, Eberle, & Dorsey explain that, “To non-scientists, the word theory often means a hunch, opinion or a guess” (2008). In contrast, a scientific theory is “evidence based explanations based on related observations of phenomena or events” (Keeley, Eberle, & Dorsey, 2008). By establishing a common scientific vocabulary in their own classrooms, teachers can ensure all participants are on the same page. The training conducted in LTT emphasized a common starting point, based on vocabulary, for all teachers involved in the workshop. In an effort to highlight theory as a tool, teachers “need to become proactive in the way they teach evolutionary theory by representing theories as tools that biologists use, much in the same way as doctors use diagnostic tools” (Scharmann, 2005). When teachers see theories as tools in science this helps to improve instruction in the nature of science.

Thus, understanding the nature of science is an appropriate strategy to introduce evolution, and may even help to relieve some of the controversy surrounding evolution instruction. In *Better Biology Teaching by Emphasizing Evolution & the Nature of Science*, Nickels, Nelson and Beard describe a model that has been effective in improving evolution instruction that "combines the teaching of evolution with a modern view of the nature of science (which enables teachers to deal with potential controversy in a very effective manner)" (1996). One of the assertions within the nature of science that serves to alleviate stress for teachers includes the idea that evolution is "good example of a powerful scientific theory because it is supported by, and explains, an almost unparalleled number of strong independent bodies of evidence, predictions and confirmations" (Nickels *et al*, 1996).

Other aspects of the model introduced by Nickels, Nelson and Beard include hands-on/student centered activities so that students can "experience what it is like to do science rather than only read, or be lectured, about it" (1996). These points have been incorporated into LTT training and will be addressed throughout this report, as the teachers of evolution have essentially become the students.

Another strategy in introducing evolution in the science classroom is via the use of small group, peer discussions (Scharmann, 1994, 2005). There are three reasons for the effectiveness of small group discussions:

- Students are most active and individually engaged in learning when working in small groups.
- Discussions evoke, as reinforcers of learning, a host of more desirable affective outcomes (e.g., working, belonging, and identifying with a peer group).

- Teachers can establish greater instances of interpersonal relations (i.e., both student-student and student-teacher) during a given instructional period compared with most other teaching methods. (Scharmann, 1994, 2005)

This method of communication and reflection was employed extensively throughout the LTT training to foster new understandings for the teachers in the workshop.

Student Misconceptions 2.3

Addressing student misconceptions is another driver in the effort to shape understanding, and can help teachers to be more confident in teaching evolution. By understanding where misconceptions originated and students' explanations for their understanding, teachers can pose questions to their students to begin to confront these misconceptions and reshape their understanding. Evolution is a difficult concept to teach because students have many misconceptions "regarding the nature of science, and as a consequence the nature and role of scientific theories" (Scharmann, 1994). In addition to the misconceptions regarding nature of science, teacher participants report that students also have difficulty with appropriate vocabulary associated with evolution, and difficulty in understanding deep time, particularly the age of the Earth and the timeline of biological and geological events that make up Earth's history. This is typically difficult for students because the span of time is so large and can be difficult for them to conceptualize. Both of these were also addressed in the workshop sessions. When a teacher has knowledge of student misconceptions, it becomes easier to arm themselves with content, examples, and strategies to re-shape ideas concerning evolution. "Taking the time to elicit and examine student thinking is one of the most effective ways to support instruction that leads to conceptual change and enduring understanding" (Keeley

& Tugel, 2009). Using formative assessments in the LTT training, teachers were able to confront their own misconceptions and see potential misconceptions that their students may have concerning evolution and the nature of science. Formative assessments are used to make evident ideas that students have regarding a specific topic that their teachers may not be aware of. The hope is that by using formative assessment teachers will be able to listen more carefully to the notions of their students and then use the feedback to determine a course of action regarding instruction. This is required reflection for both teachers and students "to move their students from where they are to where they need to go in order to develop conceptual understanding (Keeley & Tugel, 2009). An example of a formative assessments used in the workshop included a series of statements about theories, where the participants had to decide which statements were, by their own definition, in fact characteristics of theories. Once they decided which statements best described a theory, participants had to reflect on what their own idea of a theory was, and thus justify why they selected each statement. The intention was to get the teacher to identify their own conceptions of scientific theory. Based on the group discussion the teachers acknowledge that they have inappropriately used the word "theory" in conversation with students. For example, asking students what their theory of a scientific experiment might be, when what they mean to ask is what their hypothesis was. This led to further discussion of what an appropriate definition of what a hypothesis is. Several participants said that they asked their students to think of a hypothesis like a prediction or an educated guess. Not all agreed with this explanation of a hypothesis. The discussion continued until there was consensus that a true hypothesis is our best possible outcome or explanation for a scientific question based on past experiences. All participants agree that the clarification of these terms and establishing a common scientific vocabulary is essential to helping students understanding their misconceptions.

Teacher Understanding 2.4

Addressing content knowledge gaps in teachers' understanding is crucial in changing the way that evolution or change over time is taught in the science classroom. What also must be considered when reflecting on what makes effective instruction is teachers' attitudes about evolution. "Research has revealed that teachers' attitudes and views about subject matter can impact their curricular and instructional decisions" (Rutledge & Mitchell, 2002). The simple fact that teachers are human indicates that judgment is frequently influenced by personal beliefs. Thus teachers' understandings, and frequently their misunderstandings, shape their students' understanding on all aspects of science, but especially with respect to ideas on evolution. It would serve all parties involved to ensure that the teacher leading the class has a coherent, complete and relatable understanding of evolution and the nature of science. This confidence gained in content knowledge can serve to motivate teachers to fully teach evolution concepts in their classes. This knowledge base also serves in guiding teachers' decision making when it comes to curriculum (Rutledge & Mitchell, 2002). "Teachers who lack an understanding of evolution and the nature of science may be incapable of making informed decisions of acceptance or rejection of evolutionary theory, as well as professionally responsible curricular instructional decisions regarding the teaching of evolution" (Rutledge & Mitchell, 2002). So, weak understanding promotes weak decision making and perhaps a muddling of evolution teaching. "Teachers who don't have a thorough understanding of the nature of science may not be able to differentiate between the scientific validity of evolution and strongly held religious views- a condition that may confound their teaching of evolution" (Rutledge & Mitchell, 2002). Therefore, it becomes clear that "professional development opportunities that promote an understanding of evolution and the nature of science, as well as effective teaching practices, must additionally be made available for biology teachers already in the classroom" (Rutledge & Mitchell, 2002). Since much of the curriculum associated with evolution and the nature of science that is presented to students is touched on in several different grade levels, the argument can be made that all science teachers could benefit from additional professional development concerning change over time.

Traditional Professional Development 2.5

Considering all of the strategies detailed earlier in this report, an evaluation of traditional professional development models should be made to identify areas in need of improvement based on a better understanding of how learners develop knowledge. Most traditional models of professional development can be summed up in the following points:

- Teacher professional development has been limited by lack of knowledge of how teachers learn.
- Teachers' definitions of the problems of practice (trying out a strategy or activity before fully implementing it) have often been ignored.
- Teaching has been described as a technical set of skills leaving little room for invention and the building of craft knowledge.
- Strategies for change have often not considered the importance of support mechanisms and the necessity of learning over time (Lieberman, 1995).

In general, traditional professional development opportunities lack "authentic opportunities to learn from and with colleagues" (Lieberman, 1995). Teachers are subjected to long days of lecture and are to memorize new skills or strategies to teach evolution. As teachers are already aware, memorization is a poor instructional strategy

(Scharmann, 1994). Rarely is there opportunity to practice what they are to take back to the classroom. In *Practices that Support Teacher Development: Transforming Conceptions of Professional Learning*, Lieberman describes most inservice or staff development activities offered to teachers as having a formal nature, which is unattached to the classroom, and consisting of a “mélange of abstract ideas with little attention paid to ongoing support for continuous learning and changed practices” (1995). Most in-service is “direct teaching”, and Lieberman encourages a movement along a continuum that incorporates more reform practices. Part of the continuum that involves “learning in school” includes more than an intake of knowledge as teachers take on a more active role in their learning. “Learning out of School” is at the opposite end of the continuum, and incorporates reform plans like creating teacher networks. The continuum described by Lieberman is re-created in Figure 1. This change from teaching to learning is significant, as it implies that teacher development leads to changes in the structure of schools (1995).

“Direct” Teaching →	**Learning in School** →	**Learning out of School**
● Inspirationals	● Teacher Scholars	● Reform Networks
● Awareness sessions	● Teacher Leaders	● School/University Partners
● Basic Knowledge	● Critical Friends	● Subject Matter Networks
● Initial Conversation	● School Quality Review	● Informal Groups
● Charismatic Speakers	● Peer Coaching	● Collaborations
● Conferences	● Action Research	● Teacher Centers
● Course & Workshops	● Story Telling	● Impact II
● Consultations	● Sharing Experience	● NEA & AFT Collaborations
	● Teaching Each Other	
	● Problem Solving Groups	
	● Descriptive Reviews	
	● Portfolio Assessment	
	● Experiencing Self as Learner	
	● Proposal Writing	
	● Case Studies Practice	
	● Standard Setting	
	● Journal Writing	
	● Working on Tasks Together	
	● Writing for Journals	
	● On-line conversations	
	● School Site Management Team	
	● Curriculum Writing	

Figure 1: Teacher Development & Professional Learning: A Continuum (Lieberman, 1995)

Issues in Reforming Teacher Professional Development 2.6

Reform efforts in teacher professional development advocate that teachers must take an active role in constructing knowledge (Lieberman, 1995). In this way, teacher learning is very much like student learning in that people learn best through active involvement and by thinking about and articulating what they have learned (Lieberman, 1995). In the LTT training significant efforts were made to make participants active learners with engaging activities and by providing opportunities to discuss their own challenges with evolution and the misconceptions they and their students have on the topic.

Classroom Disconnection 2.7

Disconnection from the classroom is another area of concern in teacher professional development. Most staff development is formal and unattached to the classroom (Lieberman, 1995). "Conventional forms of professional development are…too top-down and too isolated from classroom realities to have an impact on teachers' practices" (Corcoran, 1995). Better practices in professional development include "strategies and mechanisms that are more long ranged, more concerned with the interactions of groups and individual teachers, and often original and unique to the particular contexts in which they are invented" (Lieberman, 1995). Thus, the LTT training was focused on evolution and the teaching of change over time using the nature of science as a theme. Teachers were given the opportunity to work through new strategies and classroom ready activities and field work that can be immediately used in the classroom. In *Practices that Support Teacher Professional Development,* Lieberman suggests that "If reform platforms are to be made operational, enabling teachers to really change the way that they work, then teachers must have opportunities to talk, think, try and hone new practices, which means that they must be involved in learning about, developing, and using new ideas with their students" (1995). Teachers participating in LTT were frequently asked how they would implement activities presented in the training and how they could adapt the activities to meet their students' needs.

Teacher Networks 2.8

Teachers participating as a network of learners can be a powerful strategy for teacher professional development; however, this is not the common practice in traditional professional development workshops (Lieberman, 1995). Teachers participating in this type of collaborative learning receive many benefits from a network of teachers that are working to develop understanding of a common topic. "Networks have high credibility with teachers, and appear to have positive effects on their motivation, knowledge of pedagogy and subject matter, willingness to take risks, and commitment to improvement" (Corcoran, 1995). In addition to formal learning, teachers in networks have more conviction in the representation of their perspectives, become leaders, and use firsthand experience to create new possibilities for their students. Most importantly, teachers tend to develop a "community of shared understanding that enriches their teaching while providing the intellectual and emotional stimulation necessary for personal and enduring growth and development" (Lieberman, 1995). Teachers participating in the LTT training were networked via long term professional development sessions, and the web based discussion board where teachers could pose questions, receive advice or guidance on implementation, and celebrate success in how they taught about change over time. Each discussion prompt is related to the latest workshop session or implementation of a lesson that was practiced in the session. Examples of questions posed to the group and some responses include:

- What questions about the teaching of geology, geologic time or the nature of science do you have for your fellow participants or the participating scientists?

I would really like to know how the tectonic plates were moving around before Pangaea formed. The mountain ranges and other land features of the USA or the more well-known ones from other parts of the world - how did they get here? The Appalachians are not currently on a plate boundary, for example.

Why do tectonic plates shift directions? If North America and Africa collided to make a mountain chain on Pangaea, why did they later split up?

I'd also like to know more information about fossil animals that have been found on more than one continent, and find an easy-to-understand way to explain to students that this is evidence of continental drift.

- What books do you already use in your class or are you aware of that help teach concepts related to life through time? Why do you recommend this book?

  Lone Star Dinosaurs is a great Texas dinosaur resource. It is a bit dated (published in 1995), so just be aware that the sauropod of the Glen Rose area is Paluxysaurus, not Pleurocoelus (see p. 80-83). Even the Texas Legislature had to update the "State Dinosaur of Texas"!
- You know your students best, what do you feel is the biggest misconception that they have about life through time? Where do you think this misconception originated? How have you gone about addressing this misconception? After reading through other posts offer a suggestion to at least one participant on how you would address their students' misconceptions.

  I find that my students believe that life on Earth began with the dinosaurs and they are confused when shown a fossil that is not a dinosaur. They do not realize *how old 4.5 billion years is and they can't comprehend that life on Earth is considered in the history of Earth VERY recent.*

It's the same with my kids. I think is developmental. They don't even know things from 10 or twenty years ago (Is Abraham Lincoln still alive? is a commonly asked question).

I believe that if we want the students to be able to grasp this concept then we need to break "time" down for them. I like the activity where we break down what has happened on Earth in the span of an hour. I use the "hour" of classtime.

- Share one activity about life through time or the nature of science that you learned about in our work session that you have already implemented in your curriculum that you think the group can benefit from.

  I presented a variation of the Earth timeline we learned about in class to a group of fellow teachers. I plan to use it next year in my Science classes. I have a really COOL map of the U.S. from the USGS showing the ages of rocks in the U.S. I also have some fossil replicas. I researched the fossils and made a chart with things like scientific name, common name, organism type, interesting facts-such as what they ate and current day relatives. The fossils came with a sheet that had pictures of all the fossils as well as both scientific and common name, time period. I added how long ago each one lived. I made several copies of the pictures, laminated them, and cut them into squares. I buried the fossils. Students become paleontologists. I read "Fossils Tell of Long Ago", then pass out shoe boxes (the plastic ones you can get at Walmart for about $1) with buried fossils. Fossil tools include paint brushes, spoons, and toothpicks. After the fossil is dug and cleaned, *students find 2 pictures of their fossil. The first picture they tape to the timeline guessing how long ago it lived. The timeline is marked every 500 mil. years. The second picture they tape to the map where "if conditions were right" they might find their fossil. The student then gets the chart and fills in an activity sheet about their fossil. The last step is to take a 3rd picture and tape it in the correct area of the timeline with the periods colored. The students compare the two timelines. The teachers loved it and it went really well. I can't wait to try it with my students. I am also working on an activity with the creature cards we used. But as is typical for me I am modifying it to fit my students and my teaching style.*

Based on the responses posted on the Blackboard site, teachers were appreciative of one another's suggestions, reflections and questions. The question concerning students' misconceptions received the most views and responses. Included in these misconceptions were difficulties in understanding deep time, relative dating, common ancestry, and nature of science.

Misconceptions in Evolution Education 2.9

Students and teachers both have misconceptions that prevent them from having a better understanding of evolution. In the LTT training, one of the goals was to identify teachers conceptions related to evolution and the nature of science to help them be able to offer more complete and scientifically accurate explanations to their students. As described by Alters and Nelson in *Perspective: Teaching Evolution in Higher Education,* "Public understanding of evolution is considered woefully lacking by most researchers and educators" (2002). Despite many efforts to provide a better understanding of evolution, people are still carrying with them many misconceptions. These efforts include conferences addressing the teaching and learning of evolution, societies established to study evolution, statements issued to support evolution education by many well known science education organizations, centers to study the teaching and learning of evolution, and policy documents endorsed by many delegates of scientific societies (Alters & Nelson, 2002). Yet, even with these efforts the public tends to not have a very good understanding of evolution; perhaps there is a need to take a closer look at teaching methods when it comes to evolution. Most educators have a tendency to teach as they were taught, and that insufficient learning on controversial topics like evolution, genetics and environmental policy is the fault of the students because of their lack of effort (Alters & Nelson, 2002).

The origins of evolution misconceptions are numerous. Some are influenced by the media's communication of evolution and antievolution (Alters & Nelson, 2002). Others may not have a good understanding of natural selection or variation in a population, or may be confused by terminology (Bishop & Anderson, 1986). Additionally, there are some negative perceptions about the social and personal impacts of evolutionary theory (Brem, Ranney, & Schindel, 2003) which may prevent teachers from having a better understanding of evolution and thus could impact their teaching. It is because of these misconceptions that students fail to completely understand evolutionary concepts (Alters & Nelson, 2002).

Addressing the concepts that teachers have about evolution is one of the goals of the LTT training. It is clear that students conceptions are effecting how and if they learn, therefore, these conceptions should be uncovered and addressed (Alters & Nelson, 2002). Without addressing these prior conceptions, it will be difficult to grasp new concepts and information. Even worse, they may learn the information for testing purposes and then quickly revert back to their initial conceptions outside of the classroom (Alters & Nelson, 2002). In *Perspective: Teaching Evolution in Higher Education*, Alters and Nelson identify five groups of misconceptions summarized here:

- *From-experience misconceptions*: These are misconceptions students surmise from their everyday life. For example, mutations are always detrimental to fitness.
- *Self-constructed misconceptions*: This happens when new information conflicts with what the students already "knows", but rather than change their misconceptions, they accommodate the new knowledge in the framework of an old conception. For example, students who think that evolution is progressive and that humans are the end goal will incorporate natural selection into that type of determinism.
- *Taught-and-learned misconceptions*: These are unscientific facts that have been taught to the student by parents, teachers, or unconsciously learned from fiction. For example, the thinking that humans and dinosaurs co-existed because of seeing them in films, books or cartoons.
- *Vernacular misconceptions*: These arise from the casual exchange of scientific vocabulary with common vocabulary. One of the most prevalent examples is that of evolution as only a "theory".
- *Religious and myth-based misconceptions*: These are concepts in religious and mythical teaching that when transferred to science become factually inaccurate. Two examples of this are that organisms are not descended from one ancestor, and that the Earth is too young for evolution and most geological processes to have occurred (2002).

Identifying participating teachers' misconceptions will help them find better ways of explaining concepts related to evolution and the nature of science. Once teachers have experienced confronting misconceptions, they should be able to assist their students in doing the same.

Steps in Reform 2.10

The challenge comes in how to go about reforming teacher professional development. Obviously the first step is to move from a direct teaching approach in professional development to one that actively engages learners in the construction of knowledge (Corcoran, 1995). In *Helping Teachers Teach Well: Transforming Professional Development*, Corcoran details guiding principles of promising reform-based professional development programs. Included in his discussion are points such as: stimulating and supporting site based initiatives have greater impacts and improve practices; effective practices are grounded in knowledge about teaching; they model constructivist teaching; offer intellectual, social, and emotional engagement with ideas, materials, and colleagues; demonstrate respect for teachers as professionals and adult learners; allow for reflection and follow up support for teachers implementing new content; and are accessible and inclusive (1995).

The question remains, what is the effect of a reform-based professional development series on how teacher approach teaching evolution? Though many see evolution as a topic to be covered in high school biology, laying the groundwork of understanding begins in elementary school. Additionally, Nickels, Nelson and Beard state "critical thinking skills should be the most fundamental part of any science course" (1996). Evolution education offers a great opportunity to build critical thinking skill by emulating the critical thinking skills that scientists use in "evaluating the relative merits of alternative explanations" (Nickels *et al*, 1996). These skills should be built upon year after year, "…teachers should use evolution as an ideal opportunity for illustrating the nature of modern science" (Nickels *et al*, 1996).

By offering a more constructivist approach to professional development training, teachers will have a greater opportunity to confront misconceptions, gaps in content knowledge and reflect on best practices that lead to changes in their own understanding. It is this change in personal understanding that is crucial to effecting change in a teacher's delivery of instruction. Confident teachers are more likely to step up to teach at a higher level (Corcoran, 1995). Teachers who are supported by a collaborative group and feel as though they have group of voices supporting their efforts are more likely to create new experiences for their students in science (Lieberman, 1995).

Conceptual Change 2.11

Although understanding of how knowledge is restructured involves several aspects of philosophical, psychological and pedagogical questions, we can clearly identify shifts in perspectives that lead learners to the next step of understanding (Scharmann, 1994). In the conceptual change approach to teaching science, four conditions must be met for conceptual change to take place:

1. Existing ideas must be found to be unsatisfactory.
2. The new idea must be intelligible, coherent, and internally consistent.
3. The new idea must be plausible.
4. The new idea must be preferable to the old viewpoint on the grounds of perceived elegance, parsimony and/or usefulness (Scharmann, 1994).

Teachers, or in this case professional development leaders, must remember that for conceptual change to take place traditional "teacher-centered" instruction is inadequate. Enhancement of conceptual change includes strategies such as allowing students (in this case teachers receiving professional development) to express their initial ideas, encouraging student to student interaction, facilitating teacher to student interaction, and providing opportunity for reflection (Scharmann, 1994). All of these strategies for encouraging conceptual change suggest that these changes best take place in an environment where learners are actively engaged in the instruction.

Cognitive Reconstruction of Knowledge Model 2.12

When planning effective professional development, how participants construct knowledge in an important consideration. There are several models in literature about how learners actively construct knowledge. Dole and Sinatra propose the Cognitive Reconstruction of Knowledge Model, which ties together research from psychological perspectives, science education research and social psychology (1998).

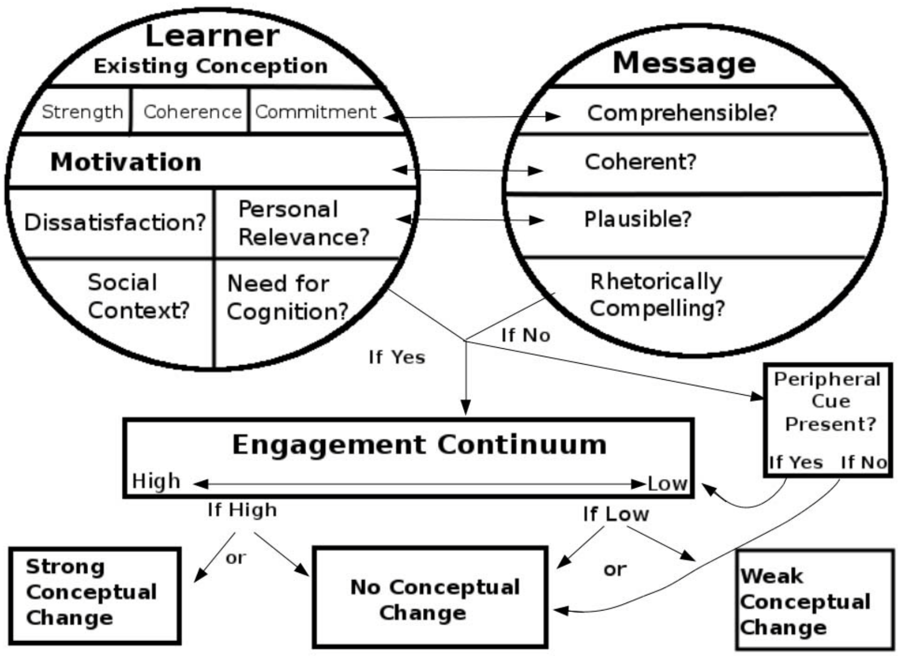

Figure 2: Cognitive Reconstruction of Knowledge Model (Dole and Sinatra, 1998)

Figure 2 is a representation of the steps in reconstruction of knowledge, reconstructed from *Reconceptualizing Change in the Cognitive Construction of Knowledge* (Dole & Sinatra, 1998). The model is based on the interaction of learner and message characteristics. The learner enters the model with existing conceptions surrounding an idea or topic. Understanding these conceptions is essential in understanding the knowledge reconstruction process. These conceptions can often conflict with the processing of new knowledge. There are three qualities of these conceptions that can influence likelihood of change: strength, coherence and commitment. The strength of the conception describes how well formed existing ideas are. Coherence details whether or not the existing conception provides a sufficient explanation to leave no loose ends. Concepts that lack coherence are more likely to change. Commitment to a conception can be shaped by social groups, culture, or experience. Learners that are very committed to their conceptions are less likely to change. The learner's motivation to process change can be influenced by dissatisfaction, similar to cognitive dissonance. This cognitive dissonance is the uncomfortable feeling that a learner experiences when they have to reconcile two conflicting ideas. Motivation can also be influenced by personal relevance. Personal relevance is defined as having a personal interest in the outcome, or an interest in the topic. Another motivational factor is affected by the group's social contexts. If the learner holds the instructor in high esteem, he/she generally displays more motivation to change. The final factor involving motivation in the model is cognition. Some learners are by nature cognitive-- they are interested in learning for the sake of learning, and they have an inherent need to process information, which motivates them. These four elements are not the only sources of motivation for change, but are the most likely (Dole & Sinatra, 1998).

On the opposite side of the model there is an evaluation of the message. Much like the Conceptual Change Model, the message presented to the learner must be comprehensible and plausible. A message that is close enough to what the learner already knows is more likely to be incorporated into their understanding, and for the message to be plausible the learner has to believe that the message could be reasonably true. Both of these characteristics must be satisfied to elicit change in the learner. The message must also be coherent, in that it offers an explanation for phenomena. Finally, the message must be rhetorically compelling, so that the learner sees the message as convincing or persuasive. Both the existing conceptions and motivation determine the quality of the message (Dole & Sinatra, 1994).

Dole and Sinatra's Cognitive Reconstruction of Knowledge Model (CRKM) proposes a continuum of processing information that spans from low cognitive engagement to high metacognitive engagement. The high elaboration happens when the learner is involved in meaningful analytical processing of information. More superficial processing of information allows for assimilation, but not significant change to original conceptions (Dole & Sinatra, 1994). The obvious choice would be to encourage learners in professional development to engage in information processing at the highest level. This would require the learner to "not only engage in the cognitive strategies of connecting and comparing existing concepts with new information, but they would be reflective about what they were thinking and why" (Dole & Sinatra, 1994).

In an effort to present teachers a well-formed message and the opportunity to interact with the message, LTT training considered several aspects of the workshops. The message of evolution is at the highest end of the engagement continuum, therefore, LTT training incorporated a well supported theory (evolution) and allowed teachers to identify and reflect on their own conceptions. Facilitators of the training presented the message via experts in a supportive environment, with the opportunity to actively engage in the lessons. Participants were asked to reflect on the learning process, how their thinking had changed and what the implications of this new knowledge would have on their classroom instruction.

Chapter 3: Workshop Methods: *Methods 3.1*

The methods for this research on professional development are of a qualitative nature and consist of reflective data collected during the workshop (IRB Protocol Number: 2010-08-0019). Since the workshop is still in progress, it is important to note that the analysis is of data that reflects teachers' perceptions of their attitudes halfway through the training sessions.

As previously described, the purpose of this research is to assess the effect of a reform-based evolutionary biology professional development series on 4th through 8th grade teachers' approach to teaching evolution. The 11 month training program focused on 4th-8th grade teachers and took place at The University of Texas at Austin's main campus, the Brackenridge Field Laboratory, and the J.J. "Jake" Pickle Research Facility. Field trips associated with the sessions included visits to the Texas Natural Science Center, both the museum and the collections facilities; the Austin Core Research Center; the High Resolution X-ray Computed Tomography Facility; and fossil locations in Central Texas.

Participants for the workshop sessions were recruited using self-selected sampling methods; they were required to submit applications to participate in the LTT sessions. The application requested information about current teaching assignments, classroom and campus demographics, preparation for coursework, interest in attending the workshop series, and how they would in turn share what they learned in the training with other teachers. Applicants were also required to submit a letter of support for their campus principal, which states that the principal is aware of the commitment that the applicant is making. In some cases with self-selected sampling, a biased sample may result. This was not an area of concern as this research is not intending to make generalizations about an entire population, but rather to examine the effects of a training program on a group of teachers who are interested in learning more about evolution and life through time. The applicants are demonstrating this desire through the time commitment for this training, as well as the other requirements of the professional development series.

Participants were recruited primarily from Manor Independent School District (MISD) teachers and the Central Texas Regional Collaborative for Excellence in Science Teaching (CTRC) because they are grant partners for this training session. Other 4^{th} -8^{th} grade teachers were also permitted to apply. MISD consistently records Texas Assessment of Knowledge and Skills (TAKS) scores that are below the state average and the demographics of the district reflect students that are typically under-represented in the sciences. CTRC provides high-quality, continuous, Texas Essential Knowledge and Skills (TEKS)-based professional development to science teacher mentors. CTRC helps to build leadership skills of participating teachers as they return to their campus/district and provide professional development to their peers. CTRC works with teachers from across Texas' Region XIII, which encompasses 60 school districts, grades K-16. With 50+ Science Teacher Mentors and 200+ Cadre Members the content and pedagogy knowledge gained through CTRC's professional development affects thousands of children in Region XIII.

From the application pool, 20 science teachers were selected that meet the following criteria: teach 4th-8^{th} grades, teach a demographic of students that are traditionally under-represented in the sciences (including Hispanics, African-Americans and females), and have a way to incorporate lessons related to life through time in their classrooms. Demographics of the participants and their schools are found in Table 1 and Table 2.

Gender	**Race**	**Teaching Experience**	**Grade Level(s) Currently Teaching**
Male: 9	Native American: 1	1 yr: 1	Elementary: 12
Female: 11	Hispanic: 5	2-5 yrs: 7	Elementary & Middle: 2
	Caucasian: 14	6-10 yrs: 6	Middle: 5
		11-15 yrs: 3	Middle & High:1
		15-20 yrs: 2	
		35+ years: 1	

Table 1: *Participant Demographics: Personal Information and Current Teaching Assignment*

Title 1 School	**School Type**
Unknown: 1	Private: 1
No: 3	Charter: 3
Yes: 16	Public: 16
Unknown: 1	

Table 2: *School Demographics*

Since the application pool was greater than 20 teachers, priority was given to the two partner organizations, MISD and CTRC. Other criteria to select participants included years of teaching experience, hours of college course work in science, and openended responses to questions related to why the participant was interested in the program and how curriculum would be shared with colleagues after participating in the workshop series. Since research evaluators are only fluent in English, all participants must be able to speak, read and write in English fluently. Other factors such as age, gender, and ethnic background had no bearing in the selection process. All participants must be of legal age and fully able to freely give consent for participation. Other participant demographics considered in the selection process are detailed in Table 3.

Certification	**Field of Undergraduate Degree**	**Field of Graduate Degree**	**Science Undergraduate and Graduate Level Coursework**
Unknown: 1 Science: 7 Generalist: 12	Unknown: 1 Science-related field: 8 Other field : 11	Science-related field: 2 Other field: 4 No graduate degree: 14	Average number of total science hours: 35 Range of total science hours: 6 to 97 hours Average number of hours in : o Biology: 18.6 o Chemistry: 5.1 o Physics: 3.9 o Earth Science: 4.6 o Space Science:2.7

Table 3: *Participant Demographics: Certification Type and University Preparation*

Over the course of one year, participants will attend nine, day long training sessions exploring life through time at The University of Texas at Austin - two, day long sessions were held in the Spring of 2011, a five day institute was held in the Summer of 2011, and two, day long training sessions will be held in the Fall of 2011. Funding for the professional development program is being provided by the Institute for Museums and Library Services *Museum for America* grant, as well as the Texas Natural Science

Center. Each workshop sessions is based on the state and national science education standards. Key concepts to be covered throughout the workshop series include: the nature of science; introduction to geology; fossilization processes; sedimentary rocks and processes; geological time; plate tectonics; basic morphology and biodiversity of vertebrate groups and the roles of fossils in our understanding of macro-evolutionary change; organisms and their environment; environmental change, evolution and extinction; and the Tree of Life.

All workshop sessions were co-taught by University of Texas at Austin (UT) scientists and science educators, and a Master Teacher from a public school setting. This researcher participated in the workshop development as the Master Teacher. The responsibilities of the Master Teacher included planning, modifying and teaching lessons; working with small groups; correlation of state standards to the lessons at hand and coordination of the workshop sessions. During each session, a research scientist from UT discussed his/her current research with the participants; participants conducted hands-on labs and/or field activities to deepen their understanding of the presented concepts and to gain opportunity to integrate the discussed concepts directly into classroom curriculum. Participants received multiple curriculum guides and permission to borrow science teaching equipment and specimens for use in their own classroom or for teacher training. Participants went on multiple field trips to scientific laboratories at UT and to Central Texas fossil field localities to allow for further exploration of topics covered during the sessions.

In addition to attending the training sessions, teachers agreed to collaborate with other participants, and TNSC scientists and science educators, by participating in a web-based forum throughout the entire series of workshop sessions to share lesson ideas and resources, further connect what they learned during training to their own teaching, ask questions about content or pedagogical issues, and reflect upon their learning. Participants used the knowledge, skills, and resources gained during the sessions to train for six hours at least five other teachers at the local, regional or state levels in the project curriculum.

Data Collection and Analysis 3.2

Throughout the workshop sessions, a variety of sources of data were used including: applications to participate in the study, teachers' evaluation of the professional development series, and reflection sheets presented at the culmination of each of several workshop days.

Teacher demographics provide descriptive information about the participants and include information that details current teaching assignments, length of teaching experience, campus and classroom demographics, coursework taken, and reasons for participating in the professional development.

In the evaluation of the workshop series, participants were asked to reflect on their perceived value of the content presented in the sessions. The participants were asked to evaluate several aspects of the training; the questions most relevant to this report include: "Are the activities presented during the series appropriate for your classroom use? Why or why not?"; "What aspects of this professional development series are effective?"; and "Do you feel better prepared to teach science using an integrated life and earth science approach as a result of attending this professional development series? Why or why not?" An example of this evaluation is included in Appendix of this report.

The first relevant question, "Are the activities presented during the series appropriate for your classroom use? Why or why not?" is an important one to consider because as explained in the literature review, effective professional development connects teacher learning to classroom needs (Lieberman, 1995). If participating teachers do not make the connection between what is learned in professional development and the classroom, they will not be inclined to implement changes to their curriculum. Additionally, some teachers who receive professional development are presented with material that is not relevant to what they present in their classrooms and they perceive the training to be a waste of their time. If the expectation is that teachers will use this experience in professional development to make changes in their pedagogy, instruction and/or gain confidence in teaching evolution it is imperative that they be able to connect to material presented at each session. Review of teacher responses to this question shows that of 20 evaluations completed, only 2 felt that the material presented in the workshops was not appropriate for their classrooms. Of the two "no" responses given, one participant felt that the materials and activities were not geared to the 4th grade TEKS (See Figure 3).

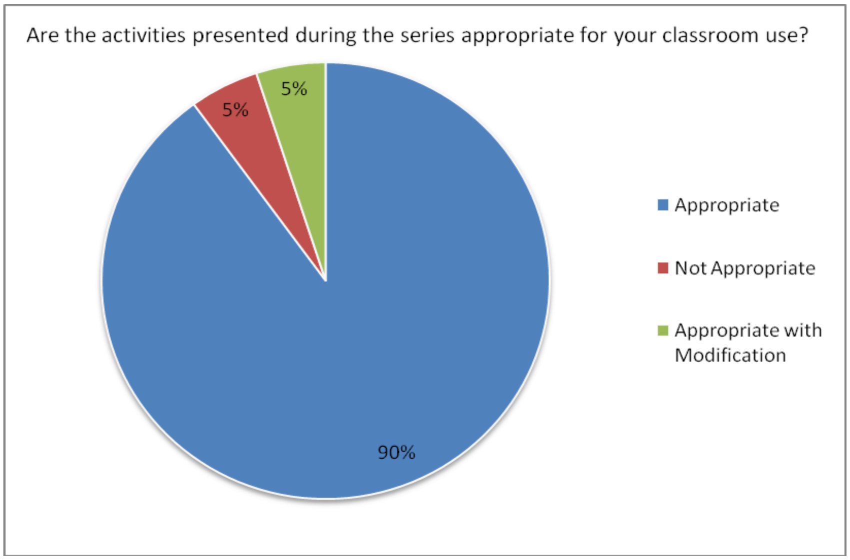

Figure 3: Appropriateness of Classroom Activities Presented in LTT Training

This same participant explained that "My students typically do not tend to be thinkers, so some activities would help them develop thinking." What is discernable from the evaluation is that the activities presented can actually be used to help develop critical thinking skills in the students of this participant, though he/she did not think the sessions specifically covered the TEKS for 4^{th} grade. During the LTT sessions, teachers were provided the TEKS alignment for all activities and all sessions presented were aligned with the TEKS. It is important to keep in mind that the TEKS are not all inclusive in detailing all aspects of science that are necessary to build a better student of science. Though not explicitly stated as an objective in the TEKS, the skill of critical thinking is an important underlying skill that is necessary for understanding and re-shaping misconceptions. The second participant that responded initially that the activities were not appropriate for classroom use clarifies in their evaluation that "…all activities can be changed to be used at my grade level." This would imply that the lessons or materials are classroom appropriate with some modification for specific grade levels. In fact this was the opinion of 6 other participants as well, that all materials were valuable and relevant, but would require some modification for their particular classroom or grade level. The remaining 12 participants felt that the materials could be implemented immediately in their own classrooms.

In evaluating responses to the question, "What aspects of this professional development series are effective?" participants cited a variety of points. Many of the effective practices used in the LTT training are, by design, based on those described in the literature review. The participants' lists of effective practices included: hands-on activities, the ability to borrow resources that are expensive, the sequencing of activities, content and field experience, classroom-ready materials, group discussion with peer groups, knowledgeable presenters, real-world connections, and addressing misconceptions. As reviewed in the literature section, effective professional development creates opportunities for participants to engage, practice, and reflect on learner-centered activities. Careful planning and many choices were made in the pacing and sequence of the materials presented in the workshop sessions based on teacher feedback on what they felt would be useful in their classrooms. Efforts were made to be sure that the training incorporated many of the suggested reform practices discussed in the literature review, such as a network of teachers, long-term training, collaboration and time for reflection. By demonstrating a sample sequence to life through time, teachers were able to consider how these same lessons or activities could fit into their existing curriculum or how they could modify their curriculum to include more evolution learning. In other responses to "What aspects of this professional development series are effective?" one participant appreciated the "sequence of presenting information, using the information to complete activities, and reviewing activities." This example shows that this participant is contemplating their own sequence and considering modifications to incorporate a more complete lesson delivery. Another participant reported "I liked the sequencing of the activities because that helped me process the 'Life Through Time' concept in a way that will help me continually spiral science lessons through the concepts taught at 4^{th} grade." This is another example of another participant considering changes to the current sequence of material in their classroom, and effecting change in student learning by connecting related concepts. Several participants were appreciative of resources and materials that were not provided for in their on-campus budget but could be borrowed through participation in LTT. One participant commented, "…and the resources that can be borrowed, e.g. looking at the skulls. Skulls are expensive, borrowing is not." Another mentioned "Providing skulls, other materials for teachers to borrow! *Most useful!"

The opportunity to make the experience of professional development personally relevant and something to gain from is an important aspect of effective professional development. Many of the participants appreciated the opportunity to reflect with a group of their peers. By doing so they could discuss student misconceptions, best practices, pose questions to the group or science experts and plan for implementation. All of these are essential for implementing change in the classroom and in their teaching strategies. Participants were asked to describe "What aspects of this professional development series are effective?" Included in their responses were comments including, "…it was nice to hear from many different people who were experts on the subjects."; "…professionals discussing what they do in their field."; "…I'm gaining great ideas of what to do with my kids."; and "…discussing with other teachers how to best utilize the activities in our classrooms."

Finally, in reviewing how this structure of professional development has shaped their ability to teach evolution, the question, "Do you feel better prepared to teach science using an integrated life and earth science approach as a result of attending this professional development series? Why or why not?" was evaluated. Feedback from teacher participants was a resounding yes. Many attributed their strong positive response to the quality of the material presented and the fact that they gained new content knowledge. Participants felt that because they have access to resources that they could re-educate themselves or seek the answers to questions that students have surrounding life through time. By allowing participants to practice using the formative assessments borrowed from *Uncovering Student Ideas in Science*, they were able to see what their current understanding or conceptions were, related to evolution and the nature of science. In this reflective practice they were asked to identify their thoughts on a particular topic, for example what is a theory, and then explain how they come to their own understanding. Several interesting conversations arose from these types of activities where the participants admitted that they felt that they were using the wrong definitions in teaching scientific vocabulary. It is this un-packaging of understanding and re-shaping of knowledge that was one of the goals of the LTT training. Teachers would then be able to implement this type of assessment and reflection with their own students. Many felt that gaining content knowledge allowed them to make connections across science disciplines, while another recorded that "I learned a great deal and became better prepared to answer questions." One participant felt encouraged by seeing the connections between life and earth science and reported, "Yes, I can better see how everything interrelates to each other, like chemistry and rocks…who knew!?!" Another participant appreciated the opportunity to consider their own conceptions about evolution in a supportive environment by reflecting, "Yes, this course has helped me so much to clear up some of my misconceptions that I had been teaching." A point can be made here that because this particular participant has identified and corrected their own misconception that the process can be replicated in their own classroom when addressing student misconceptions. Another participant indicated that their comfort level with teaching evolution improved through the training by stating that, "There is a lot of geology to teach when you talk about fossils/evolution. I knew this but I now feel more comfortable teaching it." This is the confidence that professional development must instill in teachers if change in instruction is expected.

In addition to the feedback given in the evaluations, teacher reflections were reviewed from several days of training. It is evident that participants perceive themselves to be better prepared to deal with questions from students; they perceive to have a better understanding of the nature of science; and that they have perceive to have acquired content knowledge that extends their understanding of science and that will help them make better informed curricular decisions.

In reflections from the beginning of the workshop sessions, teachers were clarifying their understanding of the nature of science. Based on their reflections that were in response to the question “What were the most important things you learned today?” it was clear that some had not been using clear scientific vocabulary and perhaps had allowed some student misconceptions to go unchallenged. For example, one participant recorded, “The exact delineation between laws and theories was helpful. I never distinguished between the two.” Without the opportunity for the teacher to discuss these important aspects of the nature of science, students in their particular classroom may not understand the difference between the two either. On every reflection sheet provided, the participants noted that their content knowledge had increased because of participation in the workshop sessions. Participating teachers reported that this increase in content knowledge has encouraged them to teach to another depth of knowledge and to pose better questions to their students. The group discussions where participants shared these changes gives partial insight into how the work done in the sessions on lesson planning, questioning strategies, and sequencing is being implemented in the classroom. Actual quantitative data on acquired content knowledge can be reviewed after the entire workshop session has concluded by comparing pre- and post-assessments.

In one reflection activity teachers were presented with the following scenario, “One of your students was standing in line at the supermarket and saw a tabloid on children who have a condition causing excessive facial hair growth. Some students are concerned that humans are evolving to have more facial hair.” Participants were then asked “How would you help them to explain to students how evolution happens at the population level, not at the individual level?" A copy of this reflection is included in the Appendix. Each response given on the reflections demonstrated a better understanding on the participants' part that evolution does happen at the species level, rather than the individual level; that natural selection would have to favor the development of excessive hair; and that this process involves the transfer of the favored alleles over a very long period of time. One sample responses includes "I would use information about adaptations and how it doesn't happen quickly." This participant is reflecting on the discussion about the length of time it takes to see changes in a population. Another response was, "In populations the organism either has the gene or it does not. Those organisms that do not have the gene cannot pass it to their offspring." This participant is using this reflection to demonstrate that it is the transfer of inherited traits that results in change, not that the organism changes out of need. Another participant explained that "Those with more facial hair won't have more children than others (unless it is somehow beneficial), but the genes are contributed to the gene pool of an entire species." This demonstrates that the participants have formed a basic knowledge of at least one evolutionary concept, natural selection.

Conclusions 3.3

Based on the qualitative analysis from the workshop series, it is evident that a well structured professional development series can significantly impact the curricular decisions teachers make, and the way they instruct their students. The teachers who participated in the Life Through Time training to this date have reported favorable results from the structure of the workshops, content presented, opportunities for reflection and collaboration, and a supportive environment to address their own conceptions which encourages participants to implement changes to their current teaching practices. Participants commented on one of their evaluations in response to the question, “Do you feel better prepared to teach science using an integrated life and earth sciences approach as a result of attending this professional development series? Why or why not?” Every response given was a “yes”. Participants went on to elaborate that the resources, lessons, content knowledge and support they have received so far is already motivating them to consider revisions of their classroom practices.

As described in the literature review, the series of workshops reflects best practices that are supported by Dole & Sinatra’s Cognitive Reconstruction of Knowledge Model (1998), including consideration of the learner’s motivation and the quality of the message presented in the professional development series to construct changes in understanding. The suggestion is that reform in traditional professional development is necessary, and that less effective forms can be replaced by implementing the strategies that have already been proven useful. Teachers learn in the same manner that their students do. When they are afforded the opportunity to construct their own knowledge the instruction becomes more meaningful and has the potential to be implemented into existing curriculum. This is particularly important when dealing with topics in science that can be considered controversial, such as the case with evolution. If the goal is for teachers to improve and increase the frequency with which they teach challenging scientific content, then they must be given the appropriate support to change current practices. Future emphasis should take into consideration learning styles of teacher participants to increase the uptake of new content or methodologies, a practice that is more frequently being employed with the students in the classroom.

There are some possible limitations in this research that should be addressed. Researchers are relying on what teachers report is going on or will be going on in their classrooms, and there is no follow up planned to observe the actual implementation of the strategies or content delivered during this professional development. Perhaps if this type of training were to continue it would be valuable for teachers and researchers to make classroom visits to those in this LTT network to see the strategies in action. Additionally, since standardized testing and assessment tends to be at the forefront of education and drives a lot of the strategies that are encouraged and implemented in the classroom, perhaps collecting data on the students of teachers that participate in LTT would be of value. For example, it would be interesting to look at specific student achievement scores from teachers who have and have not undergone the LTT training. Reviewing state standardized test for the objectives that address evolution or concepts of change over time would offer some insight as to whether or not student achievement is being effected by participation in LTT.

Chapter 4: Application to Practice: *4.1*

Having been a teacher participating in many years of professional development, I have a vested interest in improving traditional professional development practices. More often than not, I have spent an 8 hour day listening to strategies that are intended to improve instruction, but rarely do they ever get implemented into my curriculum because of what I felt like was a lack of time, or a short-sightedness on my part to see the relationship between life and earth sciences. I would much rather learn new techniques to improve instruction the way that has been described in this report. I feel confident that I can speak for the majority of my colleagues when I say that effective professional development includes the opportunity to practice new strategies, brainstorm or discuss methods of implementation, and continues once we leave the meeting space. Reforming professional development could really be the key to motivating teachers to implement change and improve instructional practices with their students.

I have done quite a bit of consulting over the past 10 years and have hosted multiple professional development sessions. I have tried to be sure that my own sessions follow the practice and discussion parts of the model. What I realize after observing the LTT training, is that I need to include more opportunities for reflection in my sessions. I think that by doing so, I can really encourage teacher to consider steps to implementation of new material. This same practice would be helpful in the classroom with students as well. I think that they need time to assimilate new knowledge and have time to figure out how new information sits with their current understandings. The hope is that they will be able to address their own misconceptions and edit their understanding, but I understand that this is not always an instantaneous response. New learning and understanding takes time to become processed so it can be comfortably used.

Having practiced identifying misconceptions in the LTT series was particularly interesting to me. Several misconceptions that were identified in the training were related to incorrect terminology. It seems like such a simple problem that can easily be resolved; however, without the opportunity to reflect on the words we are choosing to use to explain scientific concepts, we continue this poor practice. I found it particularly helpful for me to think critically about where my own ideas and conceptions about evolution came from and to talk through understandings with the group. Additionally, I found it very reassuring to go back to the definition of science as described by National Science Teacher's Association (NSTA), which describes "Science is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts." (2000). I think that this gave all participants a base to go forward from. We completely eliminated arguments that were related to the supernatural or un-testable phenomena. Additionally, one of the other misconceptions that we uncovered was that evolution is not an explanation for the origin of life; it simply discusses how life has changed over time. I think that there were participants who felt less threatened when we established this line of thinking, it conflicted less with religious or cultural beliefs. I know my own students entered my class with their own misconceptions, but I have not made a concerted effort to get them to identify those misconceptions and wrestle with evidence to the contrary. I think this is a highly valuable teaching strategy that I need to implement. On my campus we had a series of books that had formative assessments that we designed to do just that, but I had not used them because I could not see the value of doing so. After this experience I now value those books so much more.

I also gained so much content knowledge surrounding evolution. Prior to this workshop I had very little background on evolution, and didn't feel like I knew enough life science to give complete explanations to my own students. I could discuss lots about earth science, but didn't have the connections to life science to complete the picture for them. So with a better understanding of natural selection and that evolution is an explanation of change over time, not a definition of origins of life, I feel more confident in helping students confront misunderstandings. I don't think I realized how much opportunity I had to insert more instruction on evolution. I had previously assumed that evolution was a topic reserved for life science and had very little to do with what was covered in earth science. How wrong I was! I learned that I need to be making so many more connections for my students, and that I have numerous vehicles to do so in 8^{th} grade science. For example, during the unit on Earth's History I now have better background on fossils and fossilization to help explain relative dating to my students. I can then go further to include an explanation on radiometric dating, which would spiral back in some chemistry that is taught at the beginning of the school year. This would then help in my delivery of instruction on plate tectonics and the breakup of Pangaea. This movement of the plates will enrich what I already teach my students about physical geology and the relationship between the plates and earthquakes and volcanoes. All of these components are important pieces of evidence in how the Earth has changed over time and how these environmental changes can cause evolutionary changes within populations. This was the essence of the workshop series, to incorporate more evolution instruction in my own class and to be able to identify how to connect earth and life sciences.

I recently got a new position within my district and will be leaving the classroom. In my new position I will be evaluating teachers' instructional methods and their classroom environments. I think by having the experience in LTT I will be better prepared to look for how teachers implement new ideas in their classroom. I hope to be able to be a better evaluator of professional development opportunities so that I can make appropriate recommendations for teachers looking for new strategies and content knowledge.

Appendix

1. List the grade/subject you teach.

2. Is the content level of the professional development series appropriate for the grade/subject area you teach? Why or why not?

3. Are the activities presented during the series appropriate for your classroom use? Why or why not?

4. What aspects of this professional development series are effective? Please provide specific examples.

5. What aspects of this professional development series can be improved? Please provide specific examples.

MORE ON BACK →

6. What are you most looking forward to about the rest of the workshop series? Why?

7. What are you the least excited about the rest of the workshop series? Why?

8. Do you feel better prepared to teach science using an integrated life and earth sciences approach as a result of attending this professional development series? Why or why not?

9. What else do you need to be able to teach science using an integrated life and earth sciences approach more effectively?

10. Would you recommend this workshop to others? Why or why not?

11. Is there anything else you would like us to know?

MORE ON BACK →

Name: ____

Life Through Time Reflections, Day 4: Organisms and Their Environment

Please read each of these reflective prompts and answer them in the space provided as completely as possible.

1. How could you use the CT's Digimorph Website (www.digimorph.org) in your classroom?

2. One of your students was standing in line at the supermarket and saw a tabloid article on children who have a condition causing excessive facial hair growth. Some students are concerned that humans are evolving to have more facial hair. How would you help them understand that evolution happens at the population level, not at the individual level?

3. How do scientists hypothesize the function of unusual structures found in the fossil record?

References

Alters, Brian J., and Craig E. Nelson. "Perspective: Teaching Evolution In Higher Education." *Evolution* 56.10 (2002): 1891-901. International Journal of Organic Evolution. Web. 12 July 2011. <http://life.bio.sunysb.edu/~spgp/2004_02_10/Alters_and_Nelson_2002.pdf>.

Bishop, Beth A., and Charles W. Anderson. *Student Conceptions of Natural Selection and Its Role in Evolution*. Rep. no. L65. Lansing, Michigan: Michigan State Univ., East Lansing. Inst. for Research on Teaching, 1986. ERIC Document Reproduction Service No. ED269254. Print.

Brem, Sarah K., Michael Ranney, and Jennifer Schindel. "Perceived Consequences of Evolution: College Students Perceive Negative Personal and Social Impact in Evolutionary Theory." *Science Education* 87.2 (2003): 181-206. Web. 12 July 2011.

Corcoran, Thomas B. *Helping Teachers Teach Well: Transforming Professional Development*. Issue brief. New Brunswick: CPRE Policy Briefs, Carriage House at the Eagleton Institute of Politics, Rutgers University, 1995. ERIC Document Reproduction Service No. ED388619. *ERIC*. Web. Apr.-May 2011. <http://www.eric.ed.gov/PDFS/ED388619.pdf>.

Dole, Janice A., and Gale M. Sinatra. "Reconceptualizing Change in the Cognitive Construction of Knowledge." *Educational Psychologist* 3rd ser. 33.2 (1998): 109-28. Print.

Griffith, Joyce A., and Sarah K. Brem. "Teaching Evolutionary Biology: Pressures, Stress, and Coping." *Journal of Research in Science Teaching* 41.8 (2004): 791-809. Print.

Keeley, Page, and Joyce Tugel. *Uncovering Student Ideas in Science.* Vol. 4. Arlington, VA: NSTA, 2009. Print.

Keeley, Page, Eberle, Francis, and Chad Dorsey. *Uncovering Student Ideas in Science: Another 25 Formative Assessment Probes.* Vol. 3. Arlington, VA: NSTA, 2008. Print.

Lawrence C. Scharmann. "A Proactive Strategy for Teaching Evolution." *BioOne*. National Association of Biology Teachers. Web. 16 Feb. 2011. <http://www.bioone.org/doi/full/10.1662/0002-7685%282005%29067%B0012%3AAPSFTE%5D2.0CO%3B2>.

Lieberman, Ann. *Practices That Support Teacher Development: Transforming Conceptions of Professional Learning*. Rep. no. #SED 92-55369. National Science Foundation, 1995. 20 Feb. 2011. <http://128.150.4.107/pubs/1995/nsf95162/nsf_ef.pdf#page=58>

NSTA Board of Directors. "Nature of Science Position Statement." *National Science Teachers Association - Nature of Science Position Statement*. National Science Teacher's Association, July 2000. Web. 15 July 2011. <http://www.nsta.org/about/positions/natureofscience.aspx>.

Nickels, Martin K., Craig E. Nelson, and Jean Beard. "Better Biology Teaching by Emphasizing Evolution & the Nature of Science." *American Biology Teacher*

58.6 (1996): 332-36. *ENSI/SENSI: Papers & Articles*. University of Indiana. Web. 02 Feb. 2011. <http://www.indiana.edu/~ensiweb/abt.mcj.html>.

Rutledge, Michael L., and Melissa A. Mitchell. "High School Biology Teachers' Knowledge Structures, Acceptance & Teaching of Evolution." *BioOne*. National Association of Biology Teachers. Web. 20 Feb. 2011. <http://www.bioone.org/doi/full/10.1662/0002-7685%282002%29064%5B0012%3AHSBTKS%5D2.0CO%3B2>.

Scharmann, Lawrence C. "Teaching Evolution: Designing Successful Instruction." *Journal of Science Teacher Education* 5.4 (1994): 122-29. Print.